FOREST PEST MANAGEMENT
Pacific Southwest Region

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3430 Evaluation
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# A BIOLOGICAL EVALUATION OF PEST CONDITIONS AT SIERRA SUMMIT SKI AREA, PINERIDGE RANGER DISTRICT, SIERRA NATIONAL FOREST

PSW FOREST AND RANGE EXPERIMENT STATION
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## ABSTRACT

Sierra Summit Ski Area is located off State Highway 168 near Huntington Lake, and ranges in elevation from 7000 feet along Big Creek to 8700 feet at the summit of China Peak. Sierra Summit Inc. is upgrading the ski area as part of a three-phase development plan. Stand types include mixed Jeffrey pine, lodgepole pine, and white fir at the lower elevations, and predominantly red fir on the upper slopes. Insects and diseases encountered include dwarf mistletoe, annosus root disease, Cytospora canker of true firs, fir engraver, Jeffrey and mountain pine beetles, roundheaded fir borer, stalactiform and western gall rusts of lodgepole pine, and yellow witches' broom rust. Overall, pests are less important than silvicultural problems such as overstocking, abundant overmature trees, and difficulty of regeneration. Each stand and its major pests is discussed, and a table of applicable management options for each stand, pest, and growing site combination is presented.

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Sierra Summit Ski Area (formerly called China Peak Ski Area) is operated under special use permit by Sierra Summit Inc.. They have begun a three-phase development program designed to expand the ski area to its full potential. Phase I involves the upgrading of ski lifts and runs within the existing boundaries, and is almost complete; Phases II and III will expand the operation by construction of new runs and lifts in adjacent stands.

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The Pineridge Ranger District has prepared a Conceptual Vegetation Management Plan in order to achieve three objectives: to maintain the existing forested landscape; to improve the health and vigor of existing vegetation; and to provide for a continuous succession of vegetation. At present, the Forest is concerned that insect and disease pests may adversely affect these goals, and requested an evaluation of how pests may affect their Management Plan.

## STAND AND PEST CONDITIONS

All stands described here are illustrated in Figure 1 (page 3) in relation to existing and planned ski runs. The benefits of the management alternatives for each stand are displayed in the tables on pages 14-16, and major pest biologies are included in the appendix (pages 17-19).

### STAND NO. 1

Small RF3P stand mixed with scattered western white pine; conifers in isolated groups of 3-4 trees with considerable open space between. Dwarf mistletoe (Arceuthobium abietinum subsp. magnificae) is moderate in the overstory red fir, severe in the understory. Rapid growth is possible, as witnessed by a 24" dbh red fir that is 147 years old; release is evident at 125 years, and current radial growth rate is six rings per inch.

Without vegetation treatment, understory red fir may become severely infected with dwarf mistletoe because of spread from the overstory; regeneration may be sparse within the stand because of large rocks pushed into it from the surrounding ski slopes. Removing trees with dead tops, infected overstory, and suppressed, infected understory will reduce the effects of dwarf mistletoe, but regenerating the stand will be difficult.

### STAND NO. 2

RF4N stand with many scattered openings and some western white pine. Moderate-to-severe dwarf mistletoe throughout, Cytospora canker (caused by Cytospora abietis) is very evident. Stem breakage around stand opening from storm damage and decay; trees scarred adjacent to skid trails. In mid-slope are many 35+" dbh red fir stumps and cut stems on the ground; possibly cut to protect high-voltage power line from windthrown trees. Upper slope has many large boulders throughout. Lupine and chinquapin are the predominant ground cover, and fir regeneration is sparse.

Downed material, boulders, and herbaceous vegetation will cause natural regeneration to be spotty, and windthrow may be a threat where scattered mature and overmature firs remain after thinning.

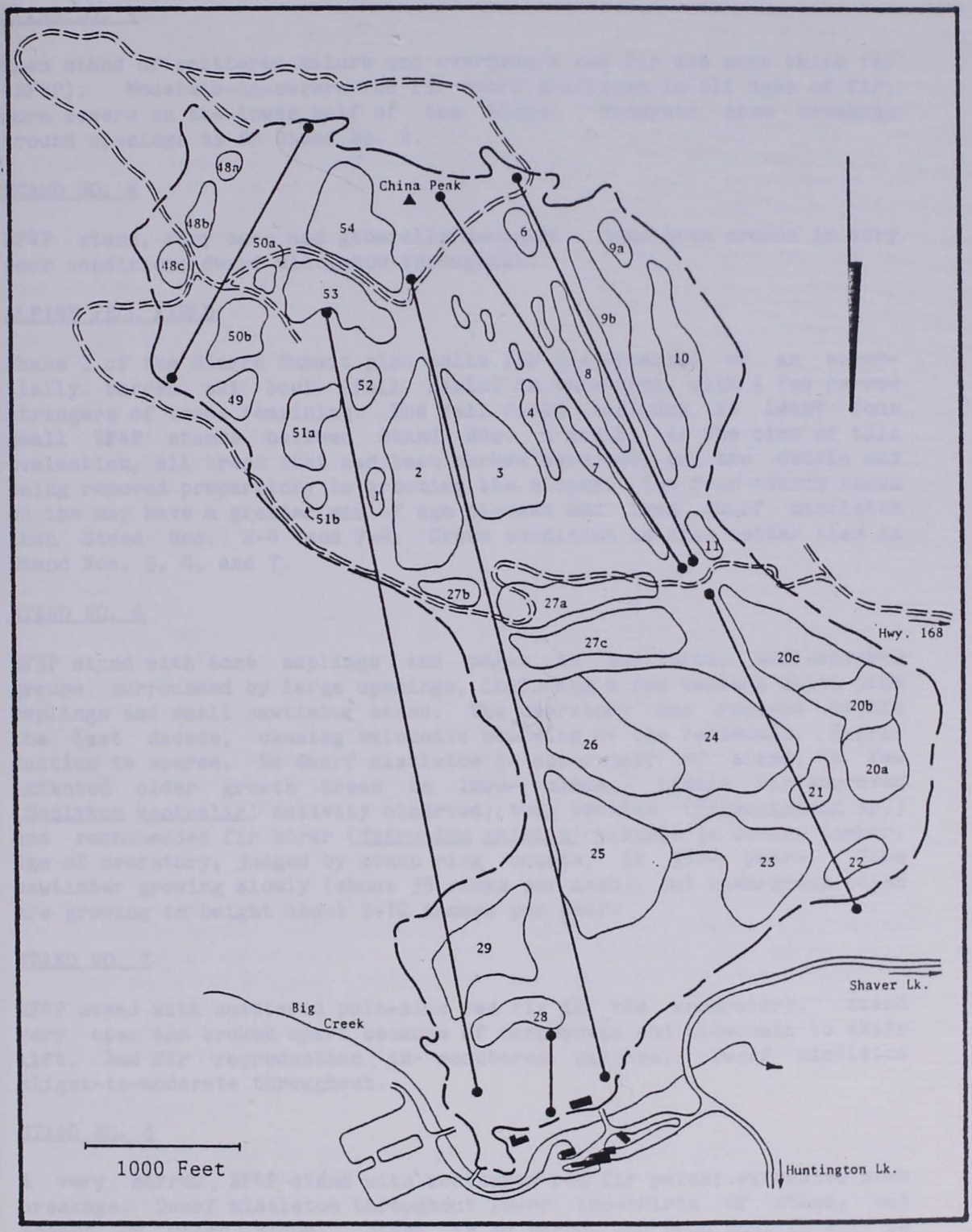


Figure 1. Conifer Stands at Sierra Summit Ski Area (formerly China Peak), Pineridge Ranger District, Sierra National Forest, August 1984.

STAND NO. 3

Open stand of scattered mature and overmature red fir and some white fir (RF4P). Moderate-to-severe red fir dwarf mistletoe in all ages of fir, more severe on the lower half of the slope. Moderate stem breakage around openings as in Stand No. 2.

STAND NO. 4

RF4P stand, very open and generally decadent. Some tree crowns in very poor condition; dwarf mistletoe throughout.

ALPINE FELL FIELD

Phase I of the Sierra Summit plan calls for the creation of an essentially barren ski bowl (fell field) in this area, with a few narrow stringers of trees remaining. The fell field includes at least four small RF4P stands between Stand Nos. 4 and 6. At the time of this evaluation, all trees that had been marked were cut, and the debris was being removed preparatory to grooming the slopes. The four stands shown on the map have a greater mix of age classes and less dwarf mistletoe than Stand Nos. 2-4 and 7-9. Crown condition is also better than in Stand Nos. 3, 4, and 7.

STAND NO. 6

RF3P stand with some saplings and poles in scattered, well-stocked groups surrounded by large openings, including a few western white pine saplings and small sawtimber stems. The overstory was removed within the last decade, causing extensive wounding of the residuals. Reproduction is sparse. No dwarf mistletoe in upper half of stand, a few infected older growth trees on lower slope. Little fir engraver (Scolytus ventralis) activity observed; twig beetles (Pityokteines sp.) and roundheaded fir borer (Tetropium abietis) visible in downed timber. Age of overstory, judged by stump ring counts, is 350+ years. Some sawtimber growing slowly (about 35 rings per inch), but open-grown poles are growing in height about 9-12 inches per year.

STAND NO. 7

RF4P stand with scattered pole-size red fir in the understory. Stand very open and broken apart because of narrowness and closeness to chair lift. Red fir reproduction in scattered patches. Dwarf mistletoe slight-to-moderate throughout.

STAND NO. 8

A very narrow RF4P stand with scattered red fir poles; extensive stem breakage. Dwarf mistletoe throughout lower two-thirds of stand, but absent on upper slope. Stand is so narrow and open that it will be difficult to maintain because of the threat of windthrow and likely problems in assuring reproduction.

STAND NO. 9A

RF4P/rf2S stand that is declining. Many trees have multiple or flat tops, indicating very poor growth and vigor. Flatheaded borers (Melanophila drummondi) and fir engraver present in downed red fir logs. Dwarf mistletoe present, but mainly evident in old stem swellings, very few plants are visible. Roughened patches on the fir bark indicate past Scolytus attacks, while pitch streamers on other trees indicated some recent engraver activity. Considerable wounding from logging activity or windthrown trees and rolling boulders. Several poles and sawtimber firs are declining with very poor crowns, but generally there are few dead trees.

STAND NO. 9B

RF4P stand with scattered, large, ragged-crowned, and dwarf mistletoe-infested trees. Stem breakage has been chronic for many years. Many firs have poor or flat tops, some crowns have foliage on one side only. Recent logging on the side adjacent to the ski lift has left the residuals open and unprotected from wind damage. White fir is mixed with red fir on the lower slopes, and is also infested by dwarf mistletoe (Arceuthobium abietinum subsp. concoloris).

STAND NO. 10

RF4P stand, very open overstory with some large firs aged 300 years or older. A history of stem breakage. Red fir understory is sparse, reproduction very scant; lupine is the major ground cover. Dwarf mistletoe infection is slight-to-moderate, severe in some trees. A white fir-red fir sapling and pole-size stand at the bottom of the slope is densely overstocked and both species of fir are infested with dwarf mistletoe. Annosus conks (fruiting bodies of Fomes annosus) present in fir stumps, but no evidence of tree killing was found around the stumps.

STAND NO. 11

LP3N stand aggregated into three groups; Jeffrey and western white pine present but sparse. Red and white fir saplings that seeded in beneath the lodgepole overstory are dying by drowning in the wet, marshy soil. Some lodgepole pines are yellow, perhaps because of the change in drainage following logging and construction in the adjacent stand uphill. Dwarf mistletoe slight and scattered in lodgepole pine. Annosus conk found in one lodgepole stump, but no adjacent mortality.

STAND NO. 20A

LPWF4N stand that is very wet, with a marsh on the upper (south) side. Mature Jeffrey pine present, with some reproduction on high, dry spots. Red fir has invaded the stand, but is dying in the wetter sites. In the marshiest areas, lodgepole pines from sapling size to 18" dbh are dying, probably by drowning in the soggy soil. Dwarf mistletoe (Arceuthobium americanum) scattered in lodgepole pine; red fir dwarf mistletoe also present. Building a ski run through the middle of this stand would greatly alter the drainage, causing further mortality.

STAND NO. 20B

Ostensibly an RFJPWF4P stand, but comprising almost equal amounts of large sawtimber red fir, white fir, Jeffrey pine, and western white pine. Understory of pole and small sawtimber red fir, western white pine, and white fir, with occasional Jeffrey pine. The stand is situated on a gentle, dry slope, with a ground cover of bush chinquapin and pinemat manzanita; it is bissected by an old east-to-west ski run. Red fir seedlings and Jeffrey pine saplings are scattered throughout the chinquapin-covered openings. Red and white fir are both infected by dwarf mistletoe and Cytospora canker. Generally, an open-grown, mixed conifer stand that is changing toward a greater abundance of fir.

STAND NO. 20C

Steeper slope than previous stand, with two distinct stand classes. On lower half and in small aggregations elsewhere, true firs dominate a WFRF5S/rf3P stand, with western white and lodgepole pines scattered throughout. On the upper slope, western white pine dominates in a WPLP3N stand with scattered white and red fir and only a few Jeffrey pine. The upper slope is generally drier and rockier, with sparse reproduction, a pinemat and chinquapin groundcover, and patches of bare, rocky soil. Openings are being invaded by true firs, but western white pine is holding its own elsewhere. The poorest trees are old-growth red firs with moderate-to-severe dwarf mistletoe, Cytospora canker, and multiple or dead tops. Except for the weakest old-growth true firs, the stand is generally open, healthy, and remarkably well-mixed, with adequate reproduction of both pine and fir. No other stand is so dominated by healthy western white pine.

STAND NO. 21

A small WF5S/rfwf3N stand with lodgepole pine in pockets and a few Jeffrey pines. Stand drainage has been altered by the surrounding ski runs and the soil is saturated in spots; many firs have lost needles and most lodgepole pines have thin crowns where the ground is wettest. However, the drainage pattern would be difficult to alter, and most of the damage has already been done. The affected area is seeding in with red and white fir, lodgepole pine, and a few Jeffrey pine. Pitch tubes of the Jeffrey pine beetle (Dendroctonus jeffreyi) were seen on a pine under stress from excess moisture, but the attacks were not great enough to kill the tree.

STAND NO. 22

A small WFRF5P stand surrounded on all sides by wide ski runs, with a drainage ditch on the upper (south) side. Ditch moderately successful in diverting most of the water from the stand. Minor species include lodgepole and western white pine. Three overstory white fir are in decline: two may die within ten years, while the third may survive for 20 or more. Red and white fir and lodgepole reproduction is adequate, even dense in spots. Red fir dwarf mistletoe and Cytospora canker present in the overstory, but most reproduction is unaffected so far.

STAND NO. 23

Eastern edge that abuts Stand No. 25 is a very open, rocky JP5S stand with scattered western white pine and western juniper. Remainder of stand to west is RFWF5N, with western white pine, Jeffrey pine, and western juniper present throughout. There are pockets of severe red fir dwarf mistletoe and Cytospora canker, but the steep slopes may make treatment difficult. A good mix of age classes and species, with plentiful true fir and pine reproduction in rocky openings near the denser stands.

STAND NO. 24

The area may be divided into two stands. On the south and north sides, it is RF5S mixed with white fir and western white pine; red and white fir reproduction very dense in spots. In the middle, on the southwest-facing, dry ridgetop, it is JP5S, with a scattered understory of true firs and western white pine and very little Jeffrey pine reproduction; openings are covered with greenleaf manzanita, bush chinquapin, and pinemat manzanita, and there is evidence that fires were once common. Yellow witches' broom (caused by the rust fungus Melampsorella caryophyllacearum) is present in some red firs, but apparently causing little damage. Overall, there is a healthy mix of ages and species, despite a trend toward greater fir dominance. On the ridgetop, careful planting and use of fire might halt the loss of Jeffrey pines. Otherwise, the stand should perpetuate itself with little intervention.

STAND NO. 25

A JP4S stand on open, rocky slopes, with western white pine and western juniper mixed throughout; white and red fir present but sparse. Some slight-to-moderate infections of true mistletoe (Phoradendron juniperinum subsp. juniperinum) on the juniper. Jeffrey pine reproduction is adequate along old skid roads, otherwise very sparse. Stand openness is caused by scattered rock outcroppings and past history of fire. Stand can be maintained with little manipulation, except for plantings where needed and the possible reintroduction of fire.

STAND NO. 26

An open, park-like JP5P stand, with old-growth white and red fir mixed in on the upper (south) slopes; western white pine, western juniper, and true fir reproduction more prevalent on the lower (north) slopes. Lodgepole pine present in a wet draw on the south side of stand near abandoned ski run. Jeffrey pine reproduction is very sparse. Pests include slight-to-moderate dwarf mistletoe in the lodgepole, and very slight-to-slight dwarf mistletoe and some yellow witches' broom in the red fir. Past history of fire suggests that underburning may be used to encourage more Jeffrey pine reproduction.

STAND NO. 27A

On the south-facing ridgetop on the east side, the stand is JP5S with scattered true firs; elsewhere it is RFWF5P. Conifers generally in groups or islands surrounded by pinemat and chinquapin openings. The Jeffrey pines are flat-topped and very slow-growing (50+ rings/inch). The old-growth red and white firs are declining, and have either dead, flattened, or multiple tops. Dwarf mistletoe common in red fir except where the fir is mixed with Jeffrey pine. Stands are very open, with few pole-size or smaller trees.

STAND NO. 27B

A two-storied RF5S/wf3N stand. Old-growth firs generally have multiple or dead tops and are declining. Little reproduction in the chinquapin and pinemat openings. The fir understory is dense in spots and may need thinning to release the better poles. Scattered sapling-to-pole-size Jeffrey pine appear to have been planted; most are growing well, although some have suffered snow damage.

STAND NO. 27C

A very open RF5P stand mixed with western white pine, white fir, and occasional Jeffrey pine. Most of the old-growth red firs have been cut, and many of the stumps contains conks of F. annosus. Existing red fir overstory moderately-to-severely infected with dwarf mistletoe. Although the stand has apparently been open for many years, and most conifers are reasonably healthy, growth has been slow; for example, one 18" dbh western white pine is growing at 35 rings per inch despite having a full and healthy crown. Reproduction is primarily red fir, but appears sufficient to maintain the present mix of species. The most suitable treatment might be removal of the red firs most severely infected with dwarf mistletoe.

ABANDONED RUN NORTH OF STAND NO. 27C

This abandoned run is now partially restocked with approximately 20--year-old lodgepole and Jeffrey pines. Undergrowth is pinemat manzanita and chinquapin. This stand illustrates how similar dry, barren sites might develop if allowed to restock naturally.

STAND NO. 28

A JPLP4P stand that includes two mature western junipers infected with true mistletoe (Phoradendron juniperinum subsp. juniperinum) throughout their crowns. Understory includes mostly pole-size lodgepole pines with scattered lodgepole, white and red fir, Jeffrey pine, and juniper seedlings. Four lodgepoles that were growing between or atop rocks had been killed by the mountain pine beetle (Dendroctonus ponderosae). Lodgepole pine is slightly-to-moderately infected with dwarf mistletoe (Arceuthobium americanum); removal of the infected pines would release and protect the lodgepole understory.

STAND NO. 29

Stand is JP5S mixed with white fir in the upper, rocky slopes to the south, and WF4N on the deeper soils to the north. Lodgepole and Jeffrey pines have seeded in heavily beneath the chair lift. Red fir of all ages is very sparse. White firs show evidence of old dwarf mistletoe infections (i.e., stem and branch swellings), but the understory does not appear to be infected. Generally a healthy stand, except for occasional decadent firs with forked or multiple tops; reproduction consists of scattered white fir and occasional western white pine. Fomes annosus conks were found in Jeffrey pine and several white fir stumps, but there was no mortality associated with these stumps.

STAND NO. 48A

An RF4P stand comprising some thirty 24-30" dbh red firs and a few old-growth trees. Red fir reproduction is very sparse, but scattered patches of seedling and sapling lodgepole pines are present. The stand is adjacent to a large rock outcropping, and the site is incapable of supporting many trees. Rodents are abundant in the openings and among the rocks, and lupine is plentiful. One old-growth red fir, weakened by a central column of decay, had broken at 15 feet above ground.

STAND NO. 48B

An RF4N stand with dense pockets of pole-size and smaller red firs; pole-size lodgepole and a few western white pines are present throughout the stand. Yellow witches' broom rust (Melampsorella caryophyllacearum) infects some of the overstory firs, but dwarf mistletoe is absent from both fir and pine. The overstocked red fir clumps would benefit from thinning.

STAND NO. 48C

An LP3G stand growing in damp soil with scattered red fir reproduction along the northeastern edge. Lodgepole dwarf mistletoe is very slight to absent, and there is little recent mortality. Thinning the weakest trees might benefit the stand, but it is probably best left untouched.

STAND NO. 49

An RF4N stand mixed with white fir, lodgepole, and western white pine. Most of the old-growth red fir have been cut, and logs and slash litter the ground, hindering reproduction. Where the ground is open and scarified, red fir and lodgepole reproduction are abundant; however, lupine has claimed some of the openings. Along the southwestern edge of the stand, red fir dwarf mistletoe is common and severe in some trees. Gophers are abundant in the openings between this stand and Stand No. 50B.

STAND NO. 50A

RF4S stand comprising nine 24-36" dbh red firs, most with fire or logging scars at the base up to 15 feet. One fir has a broken top, and

other tops are either flattened or starting to decline; there is little evidence of dwarf mistletoe. Lupine is dense beneath the overstory and fir regeneration is sparse; there is some lodgepole pine regeneration up to eight feet tall. Tops and branches of some lodgepole seedlings have been clipped by rabbits or rodents.

STAND NO. 50B

Stand is LP4P/lp2N on the marshy western half; abundant reproduction of lodgepole and scattered red fir. Pine very densely stocked in spots. Western gall rust (Endocronartium harknessii), stalactiform rust (Peridermium stalactiforme), and dwarf mistletoe are present in the pine, but causing little damage. Because of the dampness of the site, use of heavy equipment within the stand is inadvisable.

On the drier east side, the stand is RF4S, with many 40-60" fir stumps containing annosus conks; no current annosus-caused mortality is evident. Yellow witches' broom rust and dwarf mistletoe present in the fir, but generally sparse. Although the older red fir stand has broken apart, and some of the younger sawtimber firs have flat or dead tops, regeneration is abundant and the soils and moisture are adequate to support a dense stand.

STAND NO. 51A

RF4P stand that is declining, primarily from extensive dwarf mistletoe and Cytospora canker infection. Mid-bole stem breakage is common around openings; decayed, dwarf mistletoe-caused swellings contributed to the breakage. Most old-growth red fir have large dwarf mistletoe brooms, large open bole swellings, and flat, multiple, or yellowed tops. Red fir reproduction is sparse and limited to larger stand openings. Growth of younger, healthier firs is being suppressed by dominant old-growth and the spread of mistletoe from overhead.

STAND NO. 51B

A dense RF4N stand with numerous pole- and small sawtimber-size red firs that exhibit rapid height growth. An open area below (north of) the stand has seeded in with fir and lodgepole pine and, if thinned, will make an excellent replacement stand. Dwarf mistletoe is absent from both the overstory and understory.

STAND NO. 52

RF4P stand, with extensive red fir dwarf mistletoe and Cytospora canker; much of the overstory is flat-topped and declining slowly. Dense pockets of 8-16" dbh red firs are severely infected with dwarf mistletoe spread from the overstory. Openings are covered with lupine, and regeneration is sparse to absent, perhaps because of large numbers of gophers.

STAND NO. 53

RF4N stand with scattered red fir reproduction mixed with lupine in stand openings. Several overstory trees have large fire scars on the uphill (south) side, and their longevity may have been reduced. Dwarf mistletoe is scattered through the overstory. Several red fir are dying or declining next to a log deck near the top of the chair lift.

STAND NO. 54

RF5N/rf3N stand with a good mixture of ages and sizes of both red and white fir. Most of the old-growth firs are decadent, with either dead or multiple tops. Many of the older white firs are infected with dwarf mistletoe; red fir dwarf mistletoe is generally slight or absent. Reproduction is limited to the edges of the openings, which are dominated by large rock outcrops. Although large snags and leaning or decayed firs are present throughout the stand, they pose little hazard because they are generally remote from people or structures.

## MANAGEMENT ALTERNATIVES

The health of conifers in the ski area is a product of both stand conditions and the pests that are present. In general, silvicultural treatments that favor excellent growing conditions will adequately address those pests. Four prescriptions apply to the various stands in the ski area: Do Nothing, Thin, Sanitize, and Regenerate.

DO NOTHING

Some stands in the ski area currently have few pest-caused problems; in most cases, their stocking levels are appropriate for the site and age of the trees, and natural regeneration is adequate. These types of stands can be expected to maintain themselves for several decades with little or no manipulation. Since basal area will increase with time, thinning will be needed eventually to maintain the health of the stand, but it may be appropriate to do nothing at present.

Similarly, some lodgepole pine and red fir stands growing on wet sites are slightly overstocked and have low to moderate levels of dwarf mistletoe infection. Although these conditions are probably causing less than optimal growth, logging with machinery would probably increase tree stress by wounding and soil compaction. Since removal of trees in these wet areas could raise the water table, the Do Nothing alternative may be the most appropriate.

THIN

Various forms of thinning could be used in some stands to increase tree vigor, prolong stand life, and prevent or reduce pest-caused losses. In even-aged stands with no reproduction and few pests, removing suppressed and intermediate trees should extend the life of the stand, particularly

during a drought. All-aged stands with abundant advance regeneration would be thriftier and less hazardous if some or all of the old-growth overstory were removed.

This prescription would be most beneficial in true fir stands that are slightly infected with annosus root disease or dwarf mistletoe. Overstory removal would eliminate sources of dwarf mistletoe seed and lower the basal area, allowing the regeneration to vertically outgrow the upward spread of the parasite. Increased growth rates resulting from release should also allow young firs to grow roots and wood more rapidly than they are decayed by annosus root disease, which should lower the probability of premature mortality or tree failure.

A few stands in the ski area are densely stocked with saplings and poles and have few pest problems. Thinning these aggregations at an early age would prevent stagnation and reduce the chances of future bark beetle outbreaks.

SANITIZE

Sanitation will lower the basal area and may produce some of the benefits of thinning, but its primary value is to remove individual trees that pose a threat to the stand or are potentially hazardous to forest users. Trees badly scarred by construction, logging, or fire--particularly true firs wounded near the ground--are likely to become infected by root and butt rot. This may make them more susceptible to bark beetle attack or cause them to fail while still alive. Similarly, trees with dead tops are potentially hazardous to skiers, and the dead tops may become entrance courts for decay fungi.

Some old-growth trees pose a threat to other trees in the stand. Decadent trees are often more susceptible to bark beetles than younger trees, and in some cases they are sources of dwarf mistletoe seed for infecting understory trees. They may contribute to the deaths of younger trees surrounding them if pheromones emitted during a successful bark beetle attack attract enough beetles to cause a group kill. Removing green, decadent trees through sanitation can provide some protection to the surrounding stand.

REGENERATE

Several stands in the ski area have an old-growth overstory that is relatively unaffected by pests and should survive for several decades. However, the stocking in most of these stands is sparse because of fires and poor soil conditions, and they contain little or no regeneration. Future management will likely be affected if nothing is done to supply replacement trees before the overstory begins to break apart. These stands could be perpetuated if regeneration of a species and stocking appropriate for the site were established. Regeneration could be accomplished by various combinations of light sanitation cuttings, planting existing openings or those created by cutting, or using mechanical scarification or prescribed fire to prepare a seedbed for natural regeneration.

Other stands have a sparse, decadent overstory with many pest problems and little or no regeneration. In these cases, little can be done to save the stands or prolong their lives. If the management objective is to provide a safe and scenic forested area for the future, some form of regeneration harvest will be necessary. Because of the dominant use of the area, one alternative would be to sanitize the overstory to create a shelterwood, treat to reduce the gopher population, plant or scarify for natural regeneration, and later remove the shelterwood before the regeneration becomes infested with dwarf mistletoe.

Unfortunately, some sparse stands needing regeneration have already had extensive stem breakage, and further opening the stand may accelerate the process. Some of the recently constructed and groomed ski runs now support a carpet of natural regeneration that germinated in the mineral soil. Although it may be possible to duplicate this level of success in the stringers of trees between the new runs, the loss of visual diversity and ski traffic control may be incompatible with management objectives. An alternative to immediately harvesting and regenerating some of these stands would be to allow the regeneration in the ski runs to reach the height of normal snow depth, then harvest the intervening stringers of timber and convert them to ski runs.

BORAX STUMP TREATMENT. All alternatives in which live conifers are cut should include provisions for applying borax (sodium tetraborate decahydrate, EPA Reg. No. 1624-94) to prevent the initiation of new annosus root disease centers (reference FSM 2305 and 2331.33, R-5 Supplement No. 90). Borax application requires prior approval of a Pesticide-Use Proposal (FS-2100-2) by the Forest Supervisor.

## BENEFITS OF MANAGEMENT ALTERNATIVES

The benefits of applying each of the four prescriptions to stands in the ski area are ranked in the following chart. These benefits are assessed solely from the silvicultural perspective of increasing stand vigor, reducing pest-caused losses, and extending stand longevity. The rankings are likely to change if additional objectives or constraints are integrated into the prescriptions.

| STAND NO. | MAJOR CONIFERS | MAJOR PESTS | EXPECTED SILVICULTURAL BENEFITS | | | |
|---|---|---|---|---|---|---|
| | | | Do Nothing | Thin | Sanitize | Regenerate |
| 1 | RF<br>WWP | Dm<br>--- | L | L | M | H |
| 2 | RF<br>WWP | Dm,Cc<br>--- | L | L | L-M | H |
| 3 | RF<br>WF | Dm<br>--- | L | L | L-M | H |
| 4 | RF | Dm | L | L | L-M | H |
| Fell Field | RF | Dm | L | L-M | M-H | M-H |
| 6 | RF | --- | M | M-H | M-H | H |
| 7 | RF | Dm | L-M | L | M | M-H |
| 8 | RF | Dm | L | L | L-M | M |
| 9A | RF | Dm | L | L | M | H |
| 9B | RF,WF | Dm | L | L | L-M | M-H |
| 10 | RF,WF | Dm,Fa | L | H | M | H |
| 11 | LP | Dm | M-H | L | L-M | L |
| 20A | LP,RF | Dm | M-H | L | L-M | L |
| 20B | RF,WF<br>JP,WWP | Dm,Cc<br>--- | M | L | M-H | M |
| 20C | RF<br>WF,WWP,<br>LP | Dm,Cc<br>--- | M-H | L | M-H | L |

| STAND NO. | MAJOR CONIFERS | MAJOR PESTS | EXPECTED SILVICULTURAL BENEFITS | | | |
|---|---|---|---|---|---|---|
| | | | Do Nothing | Thin | Sanitize | Regenerate |
| 21 | WF,RF, LP | --- | H | L | L-M | L |
| 22 | RF<br>WF,LP | Dm,Cc<br>--- | H | M-H | L-M | L |
| 23 | RF<br>WF,WWP | Dm,Cc<br>--- | H | L | L-M | L |
| 24 | RF,WWP, JP | --- | H | (Prescribed Fire or Planting to Encourage Pine: L-M) | | |
| 25 | JP,WWP, WJ,WF | --- | H | (Prescribed Fire or Planting to Encourage Pine: L-M) | | |
| 26 | JP,WF<br>RF,LP | ---<br>Dm | M-H | L | L-M | L-M |
| 27A | RF<br>WF,JP | Dm<br>--- | L | L | M-H | M-H |
| 27B | RF,WF | --- | M | M-H | M-H | L-M |
| 27C | RF<br>WF<br>WWP,JP | Dm,Fa<br>Fa<br>--- | M-H | L | H | L |
| 28 | LP<br>WJ<br>JP | Dm,Mpb<br>Tm<br>--- | M-H | L | H | L |
| 29 | JP,WF | Fa | M-H | L | M-H | L-M |
| 48A | RF | --- | H | L | L-M | L |
| 48B | RF<br>LP | Ywb<br>--- | M | H | M-H | L |
| 48C | LP | --- | H | L-M | L-M | L |
| 49 | RF<br>WF,LP,<br>WWP | Dm,Fa<br>--- | L-M | L | H | L |
| 50A | RF,LP | --- | L-M | L | M | M-H |

| STAND NO. | MAJOR CONIFERS | MAJOR PESTS | EXPECTED SILVICULTURAL BENEFITS | | | |
|---|---|---|---|---|---|---|
| | | | Do Nothing | Thin | Sanitize | Regenerate |
| 50B | LP<br>RF | Dm,Sr,Wgr<br>Fa | M-H | L | L-M | L |
| 51A | RF,WF | Dm | L | L | M-H | H |
| 51B | RF | --- | M-H | H | L | L |
| 52 | RF | Dm,Cc | L | L | M-H | H |
| 53 | RF | Dm | L-M | L-M | M-H | H |
| 54 | RF,WF | Dm | M | M | M-H | L |

Expected Benefits: L = Low; M = Moderate; H = High

Host Tree Species: JP = Jeffrey pine; LP = Lodgepole pine; RF = Red fir; WF = White fir; WJ = Western juniper; WWP = Western white pine.

Pest Species: Cc = Cytospora canker; Dm = Dwarf mistletoe; Fa = Fomes annosus; Mpb = Mountain pine beetle; SR = Stalactiform rust; TM = True mistletoe; Wgr = Western gall rust; Ywb = Yellow witches' broom (fir broom rust).

## BIOLOGY OF MAJOR PESTS

### ANNOSUS ROOT DISEASE

Fomes annosus (Heterobasidion annosum) attacks a wide range of conifers, decaying the wood and killing the sapwood and cambium. The fungus can spread long distances above ground by air-borne spores; these are produced by fruiting bodies (conks) that develop in decayed stumps, under the bark of dead trees, or under the duff at the root collar. The spores may land on freshly-cut stump surfaces or on wounds in living trees, where they germinate and infect the new host.

Once established in a stump or tree, the fungus grows into and through the host roots until it contacts the roots of adjacent trees, where it infects and invades their root systems. In this way, F. annosus spreads from stumps or dead trees into the roots of living trees in an enlarging infection center. The fungus may spread underground into adjacent fresh stumps or recently-dead trees, but only if they are not already decayed by other fungi.

F. annosus can remain viable in infected roots or stumps for 50 years or more. Infection centers usually enlarge until the fungus reaches natural barriers such as openings or groups of non-host plants. Young conifers established within infection centers often die shortly after their roots contact infected roots in the soil.

F. annosus attacks most conifers; Pacific madrone and manzanita are the only hardwoods known to be infected. The fungus kills pines relatively quickly without causing extensive decay. It spreads through the inner bark and sapwood of the root system, killing these tissues; within 2-6 years it reaches the root crown and girdles the tree. By contrast, true firs are seldom killed directly. The fungus spreads into the heartwood of the larger roots, and then into the lower bole of the host, where it causes a butt rot. Vigor and volume are reduced, but death is usually the result of insect attack or windthrow.

Generally, firs growing within pine disease centers are highly susceptible to annosus infection, while pines adjacent to infected fir stumps usually escape attack. Thus large fir infection centers can be revegetated by planting pines.

### CYTOSPORA CANKER OF TRUE FIRS

Cytospora abietis is a canker-causing fungus that infects true firs throughout their range in California. It is a weak parasite, and usually attacks trees that have been weakened by disease, drought, fire, insects, or human disturbance. It is most commonly associated with dwarf mistletoe infection, and sometimes attacks as many as a quarter of the mistletoe-bearing branches, killing many each year. The bright red flags of recently-killed branches on dwarf mistletoe-infected red firs are almost always the result of lethal Cytospora infections. C. abietis occasionally reaches especially damaging proportions in certain years, and may attack trees of any age, sometimes killing the tops or all of young trees.

## DWARF MISTLETOES

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts. Some infect only a single conifer species, while others may attack three or four that are closely related. They rarely cross-infect from one conifer genus to another. Because of their host specificity, Arceuthobium species can usually be identified by the hosts they infect.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots, and the seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seed travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. Because of various limits to seed dispersal and the parasite's long life cycle, the actual spread rate through an even-aged stand is usually 1-2 feet per year.

Vertical spread within tree crowns varies from 3-4 inches per year in ponderosa and Jeffrey pines to 2 feet per year in Digger pines. In general, host vigor governs the rate of dwarf mistletoe intensification: dense, healthy foliage impedes vertical spread, while thin crowns are less of a barrier to the seed's upward movement.

Dwarf mistletoes are easy to identify because they are generally exposed to view within tree crowns. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached, and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings. In red fir, branch flagging usually indicates mistletoe-infected branches that have been attacked by the Cytospora canker fungus.

## FIR ENGRAVER

The fir engraver (Scolytus ventralis) attacks both white and red fir in California. Trees ranging in size from large saplings to overmature sawtimber are susceptible. Attacks can cause patch-killing of cambium along the bole, top-kill, or tree death. Top-kill or death occur most

often in firs that have been weakened by root disease, dwarf mistletoe, overstocking, soil compaction, sunscald, logging injury, or drought. The fir engraver also breeds in slash and windthrown trees.

The fir engraver usually completes its life cycle in one year, sometimes two. Adults fly and bore into trees or green fir slash from June to September; larvae, pupae, and adults over-winter under the bark. Pitch tubes are not formed as they are with pine bark beetles; the usual evidence of attack is boring dust in bark crevices along the trunk and pitch streamers on the mid and upper bole. Trees colonized early in the summer may begin to fade by early fall, but those colonized later in the year usually do not fade until the following spring or summer, often after the beetles have emerged.